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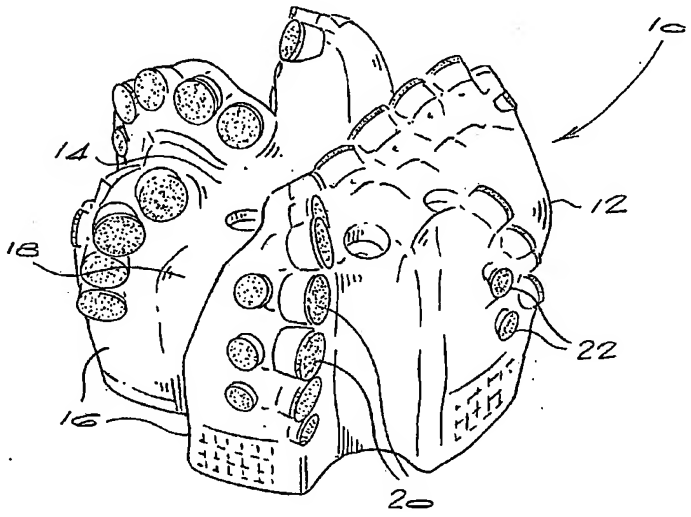
[Continued on next page]

(54) Title: SECONDARY CUTTING ELEMENT FOR DRILL BIT



(57) Abstract: A rotary drag bit comprises a bit body and a plurality of blades extending radially away from the bit body, each blade including a cutting assembly. Each cutting assembly has a plurality of primary cutters orientated in the direction of rotation of the drill bit for drilling or boring into a subterranean rock formation, and a plurality of secondary or brute cutters located behind the primary cutters in relation to the direction of rotation of the drag bit. The invention is concerned primarily with the secondary cutters, which comprise a layer of superabrasive material, such as PCD, PCBN or CVD diamond, bonded to a support substrate. The interface between the superabrasive layer and the substrate has a stepped region that provides the cutter with a skirt or hoop of superabrasive extending into the substrate. The secondary cutter is orientated in use to present a bearing surface to the rock formation and a secondary cutting edge in the direction of rotation of the rotary bit.

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BACKGROUND OF THE INVENTION

THIS invention relates to a drill bit for use in drilling or boring into subterranean rock formations, and to a tool component therefor.

Rotary drag bits or fixed cutter bits are well known drill bits extensively used in subterranean rock drilling and boring operations. They typically consist of a bit body including a first end for connecting the body to a drill string and a second working end having a number of blades extending radially from the bit body, each blade carrying a cutting assembly for boring through the rock formation. The cutting assemblies each include a number of primary polycrystalline diamond compacts or cutting elements which provide for boring or drilling into the subterranean rock formation upon rotation of the drill bit.

The drill bits also include so-called secondary cutters which are generally located behind the primary fixed cutters in critical wear areas on the drill bit wing location. They perform two basic functions. They protect the bit by providing a bearing surface in the event of the loss of a primary cutter, thus minimising the load transfer to following cutters and hence preventing a domino effect of cutter fracture or ring out. The secondary cutters also act as cutting elements in the event of the loss of a primary cutter. In view of these two basic functions, the secondary cutters are required to provide for high bearing forces and resistance to thermal induced cracking as well as resistance to high shear forces when acting as a cutting element. As a result of these non-complementary functions, conventional secondary cutters tend to be compromised in either one or both of these requirements.

SUMMARY OF THE INVENTION

According to a first aspect of the invention, a rotary drag bit comprises:

a bit body;

a plurality of blades extending radially away from the bit body, each blade including a cutting assembly;

each cutting assembly having a plurality of primary cutters orientated in the direction of rotation of the drill bit for drilling or boring into a subterranean rock formation, and a plurality of secondary cutters located behind the primary cutters in relation to the direction of rotation of the drag bit; and

one or more of the secondary cutters comprising a layer of superabrasive material bonded to a support substrate:

the superabrasive layer having a major bearing surface on one side thereof and a major interface with the substrate on an opposite side thereof,

the interface defining a stepped region in the peripheral zone of the cutter providing the cutter with a skirt or hoop of superabrasive extending into the substrate,

the or each secondary cutter being orientated in use to present the bearing surface to the rock formation and the secondary cutting edge in the direction of rotation of the rotary bit.

The interface preferably has a central table or surface which is profiled.

The profile of the table or surface is preferably a series of concentric rings, a plurality of dimples, or a cross-hatch structure.

The periphery and base of the table are generally rounded such that the interface in the region of the hoop or skirt is one which generally has no discontinuities.

The superabrasive material may be PCD, PCBN or CVD diamond. When the superabrasive material is PCD, it preferably comprises at least 25 percent by mass of ultra-hard abrasive particles having an average particle size in the range 10 to 100 microns and consisting of particles having at least three different average particle sizes and at least 4 percent by mass ultra-hard abrasive particles having an average particle size of less than 10 microns.

The invention extends to a tool component as defined above for use as a secondary cutter in a drill bit.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described in more detail, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a perspective view of a drill bit of the invention;

Figure 2 is a cross sectional side view of a tool component of the invention for use in the drill bit of Figure 1;

Figure 3a is a perspective view of a first embodiment of a substrate forming part of the tool component of Figure 2;

Figure 3b is a cross sectional side view of the substrate of Figure 3a;

Figure 4a is a perspective view of a second embodiment of a substrate forming part of the tool component of Figure 2;

Figure 4b is a cross sectional side view of the substrate of Figure 4a;

Figure 5a is a perspective view of a third embodiment of a substrate forming part of the tool component of Figure 2; and

Figure 5b is a cross sectional side view of the substrate of Figure 5a.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to Figure 1 of the accompanying drawings, a rotary drag bit or fixed bit cutter 10 consists of a bit body 12 having a working end 14 including a number of blades 16 extending radially from the central portion 18. Each blade 16 carries a row of primary cutters 20 orientated in the direction of rotation of the drill bit for drilling or boring into a subterranean rock formation. Each blade 16 also includes a row of secondary cutters 22 which are orientated generally normal to the axis of rotation of the drill bit.

The present invention is primarily concerned with the secondary cutters 22. Accordingly, referring to Figure 2 of the invention, a secondary cutter 22 of the invention consists of a layer of superabrasive material 32 bonded to a support substrate 34. The superabrasive layer 32, which in this case is formed of polycrystalline diamond, has a first or upper bearing surface 36 and a second or lower interface surface 38. The upper surface 36 includes a peripheral edge 40 which provides a secondary cutting edge for the bit in use. The lower surface 38 is bonded to the support surface 42 of the substrate 34 to form an interfacial region 46. The superabrasive layer 32 includes a recess 48 for receiving a complementary projection or central table 50 extending from the substrate 34. As a consequence of the recess 48, a hoop or skirt of polycrystalline diamond 52 surrounds the table 50. The periphery 54 and base 56 of the table are rounded. As a result the interface in the region of the hoop or skirt 52 has no discontinuities. The

support substrate material will typically be of a cemented carbide, in particular tungsten carbide.

In the cutting mode of the bit 10, the secondary cutter 22 is designed to prevent failures due to high shear forces. This is achieved by reducing the tensile axial residual stress that occurs at the periphery of the cutter close to the PCD / substrate interfacial region 46. As a result of the continuous uninterrupted hoop or skirt 52, the axial stresses are also minimised over the entire periphery of the superabrasive layer 32. Further, as a result of the recessed PCD layer, the surface area of the support surface 42 is increased, providing for greater load bearing capabilities in use.

A common problem associated with primary cutters of the type having a PCD layer bonded to a substrate is that they are prone to interfacial failures, and much focus has been placed upon designing primary cutters to reduce these interfacial failures. When the secondary cutters of the invention are forced into a cutting role, typically as a result of the failure of a primary cutter, these interfacial failures are also of concern. In view thereof, the preferred brute cutter of the invention provides for a so-called textured or profiled interface between the substrate and the PCD layer.

A number of designs for providing a greater mechanical interlocking between the PCD layer and the substrate are shown in Figures 3, 4 and 5.

Referring to Figures 3a and 3b, a substrate 60 has an upper surface 62 which is checkered or cross hatched. As a result of this profiling or texturing of the surface 62, a greater surface area is provided than would be the case for a planar surface. When forming the secondary cutter in a high temperature / high pressure operation, the lower surface of the superabrasive layer (not shown) forms a complementary interface surface. This arrangement provides a mechanical interlocking between the superabrasive layer and the substrate.

Referring to Figures 4a and 4b, the substrate 70 in this case includes an upper surface 72 having a plurality of concentrically grooved rings 74. Once again, in producing the compact, the superabrasive layer forms a complementary interface to provide the mechanical interlocking described above.

Referring to Figures 5a and 5b, the substrate 80 in this embodiment has an upper surface 82 including a number of dimples 84 in a square raster formation.

As a result of the greater surface area of the substrate and the mechanical interlocking afforded by the abovementioned designs, greater resistance to interfacial failures is provided.

Of major concern in using a secondary cutter in a bearing mode are thermally induced radial cracks. Accordingly, pronounced bar like features are avoided in the substrate designs above as these may exacerbate the hoop stress in the PCD layer as a result of too strong a mechanical interlocking effect.

A further concern in relation to a secondary cutter of the invention relates to the rate of recession of the bearing surface relative to the wear of the primary cutter. Ideally, the bearing surface must wear at the same rate or slightly faster than the primary cutter in order not to inhibit the primary cutter function. Balancing the rate of recession of the bearing surface with the peak wear of the primary cutter can be achieved in two ways. This can be achieved by balancing the wear resistance of the PCD layer or by balancing the area of the bearing surface. In view of this requirement, it has been found that a secondary cutter with a Quadmodal superabrasive layer is preferred, particularly where the primary cutter is a cutter with a multimodal (with an average particle size of about 10 µm) / Quadmodal (multimodal material with an average particle size of about 25 µm) layer, or other multi-layer, multimodal configuration. Quadmodal superabrasives are disclosed in SA 94/3645, which is incorporated herein by reference. In

general, a quadmodal abrasive comprises at least 25 percent by mass of ultra-hard abrasive particles having an average particle size in the range 10 to 100 microns and consisting of particles having at least three different average particle sizes and at least 4 percent by mass ultra-hard abrasive particles having an average particle size of less than 10 microns. Using a Quadmodal layer for the secondary cutter is also advantageous due to the proven record thereof in terms of impact resistance. However, if such a layer is still too wear resistant, a courser multimodal material could be used, for example a multimodal material having an average particle size of about 35 µm to about 40 µm.

CLAIMS

1. A rotary drag bit comprising:

a bit body;

a plurality of blades extending radially away from the bit body, each blade including a cutting assembly;

each cutting assembly having a plurality of primary cutters orientated in the direction of rotation of the drill bit for drilling or boring into a subterranean rock formation, and a plurality of secondary cutters located behind the primary cutters in relation to the direction of rotation of the drag bit; and

one or more of the secondary cutters comprising a layer of superabrasive material bonded to a support substrate:

the superabrasive layer having a major bearing surface on one side thereof and a major interface with the substrate on an opposite side thereof,

the interface defining a stepped region in the peripheral zone of the cutter providing the cutter with a skirt or hoop of superabrasive extending into the substrate,

the or each secondary cutter being orientated in use to present the bearing surface to the rock formation and the secondary cutting edge in the direction of rotation of the rotary bit.

2. A bit according to claim 1, wherein the interface has a central table or surface which is profiled.

3. A bit according to claim 2, wherein the profile of the table or surface is a series of concentric rings, a plurality of dimples, or a cross-hatch structure.

4. A bit according to any one of claims 1 to 3, wherein the periphery and base of the table are generally rounded such that the interface in the region of the hoop or skirt is one which generally has no discontinuities.

5. A bit according to any one of claims 1 to 4, wherein the superabrasive material is PCD, PCBN or CVD diamond.

6. A bit according to claim 5, wherein the superabrasive material is PCD, the PCD comprising at least 25 percent by mass of ultra-hard abrasive particles having an average particle size in the range 10 to 100 microns and consisting of particles having at least three different average particle sizes and at least 4 percent by mass ultra-hard abrasive particles having an average particle size of less than 10 microns.

7. A tool component in the form of a secondary cutter for a drill bit as defined in any one of claims 1 to 6.

8. A rotary drag bit substantially as herein described with reference to any one of the illustrated embodiments.

9. A tool component substantially as herein described with reference to any one of Figures 2 to 5 of the accompanying drawings.

Fig 1

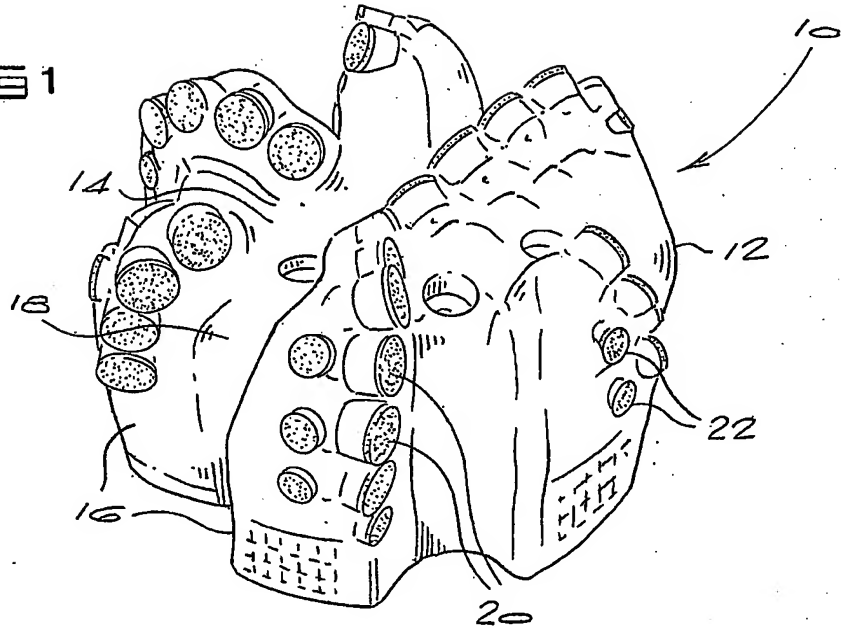
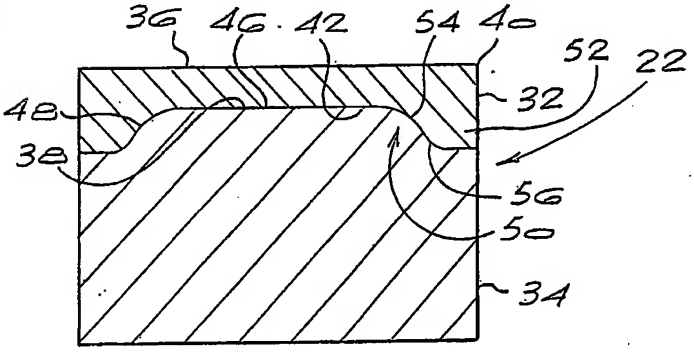


Fig 2



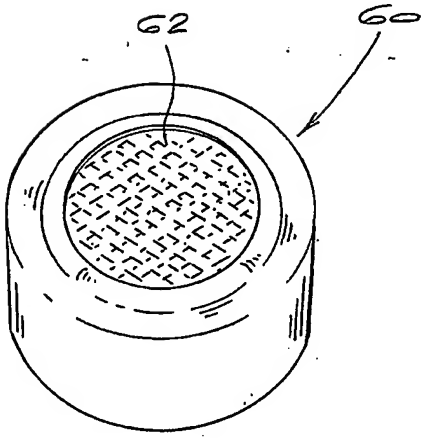


Fig 3a

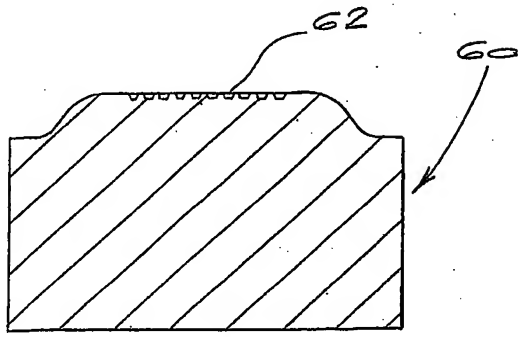


Fig 3b

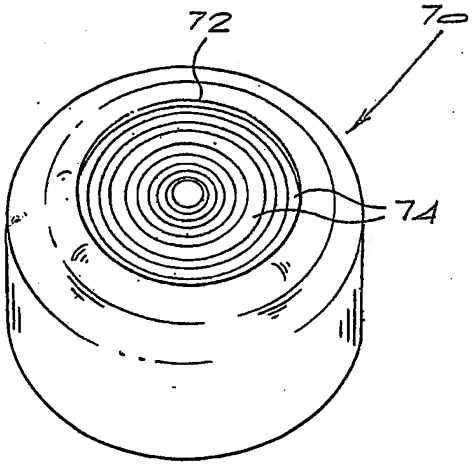


Fig 4a

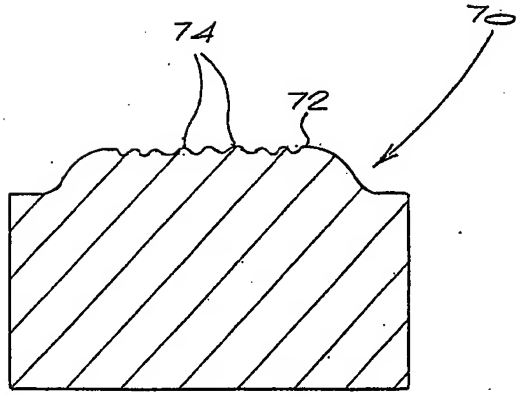


Fig 4b

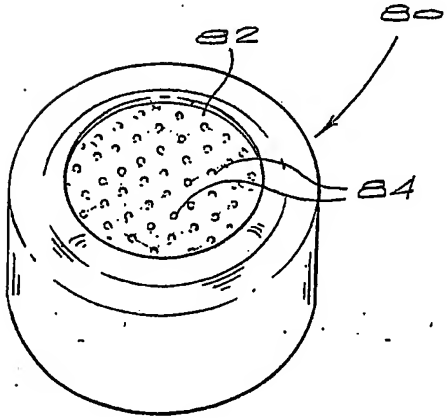


Fig 5a

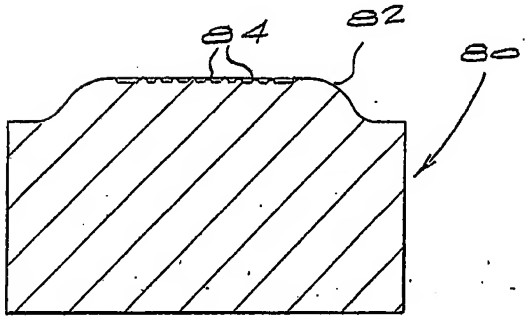


Fig 5b

INTERNATIONAL SEARCH REPORT

International Application No
PCT/IB2004/000472

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 E21B10/56 E21B10/42

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	US 2001/037901 A1 (BERTAGNOLLI KENNETH E ET AL) 8 November 2001 (2001-11-08) paragraph '0035! - paragraph '0037!; figures 4,7 paragraph '0041! ---	1-9
Y	EP 0 626 236 A (DE BEERS IND DIAMOND) 30 November 1994 (1994-11-30) cited in the application See abstract --- -/--	6

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
7 June 2004	16/06/2004

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

International Application No
PCT/IB2004/000472

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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